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NRL MEMORANDUM REPORT 1144

PROJECT ARTEMIS

FATIGUE TEST OF PRESSURE RELEASE TUBE

DOWNGRADING AT 12-YEAR INTERVALS
NOT AUTOMATICALLY DECLASSIFIED
DOD DIR 5200.10

by

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ABSTRACT

A fatigue test was run on stainless steel pressure release tubing to determine fatigue properties and stress levels caused by mechanical vibration at the resonant frequency in air. It was found that the cyclical stress level was low, on the order of 250 psi, and no fatigue problem was evident.

PROBLEM AUTHORIZATION

ONR NR 287 002 (Special)
NRL Problem Number 55S02-11

PROBLEM STATUS

This is an interim report on one phase of the project. Work is continuing.

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INTRODUCTION

A fatigue test was conducted on two sections of a stainless steel tube. These pieces were taken from a longer unit which will be used as a pressure release tube in a transducer array (figures 1 and 2). The unit is fabricated by taking a stainless steel tube with a four-inch outside diameter and a wall thickness of 120 mils and flattening it in a press to the dimensions indicated in figure 1. The tube is then assembled to the array structure as indicated in figure 2. Nitrogen gas is placed in the tube at a differential pressure of 50 psi above ambient.

PURPOSE

Since the tube will be operating in a high intensity acoustic field, it was felt that there is a danger of fatigue. This is especially evident if one considers the high residual stress which remains in the tube due to cold working during the forming operation. In order to determine if the tube possessed satisfactory fatigue properties and also ascertain the stress level for given deformations, a vibration test was performed.

TEST

Two eleven-inch sections were chosen to conduct the test (figures 3 and 4). The ends of the test specimens were left open rather than sealed as the tube will be in the final installation. This was done, since

a. eleven inches is the approximate distance between supports for the tube, and

b. the resonant characteristics of the tube would be changed if the ends were sealed.

The two specimens were then joined to steel plates to permit mounting on a vibration test machine (figure 5). Development work was done to determine a suitable epoxy bond that would withstand the vibration and stress level induced in the bonding material.

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The specimens were bonded to the mounting plates in different manners as shown by figures 6 and 7.

This was done to determine if the manner of bonding affected resonance.

The mounting plates were bolted to the test machine using the six bolt holes indicated in the sketch. The 1-1/2 inch thickness was chosen to avoid any resonances in the plate which might affect the data at the operating frequency.

As each specimen was placed on the vibration machine, it was subjected to a spectrum analysis to determine its resonant frequency.

The resonant frequencies were 533 cps and 548 cps which indicate that the bonding did not add to the stiffness of the sections. The resonant frequencies were very close to the calculated value of resonance in air for the tube.

Data was obtained by placing an accelerometer in the center of each specimen and on the steel plate. Strain gages were placed on the rounded sides near the center and end of specimen number 2. In this manner the amplitude of the driving force, that of the tube and in one case the stress level at the bend in the tube, were obtained.

The amplitude was varied for the two specimens. From the information given in table I and II it can be seen that the magnification factor is different for the two units. This is no doubt due to the greater restraint placed on specimen number 2 by the larger area of epoxy. This is verified by the fact that at similar input levels (1 g) the magnification factors retained the same relationship, indicating that the difference was due to the bonding and not the difference of input levels.

TABLE I

SPECIMEN I

Weight of mounting plate and specimen	62 pounds
Resonant frequency	533 cps
Mounting plate amplitude	422 micro inches
Amplitude of top surface of specimen	6 mils
Magnification factor	14.2
Number of cycles	16.7×10^6

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TABLE II

SPECIMEN II

Weight of mounting plate and specimen	66 pounds
Resonant frequency	548 cps
Mounting plate amplitude	2 mils
Amplitude of top surface of specimen	13.4 mils
Magnification factor	6.7
Stress in bend	±250 ± psi at end ±282 ± psi at center
Number of cycles	18.3×10^6

The driving amplitude indicated in table II was the highest obtainable due to limitations of the test equipment.

CONCLUSIONS

It is generally accepted that, if a unit can withstand 10^7 cycles of a given stress variation, it will last indefinitely. If the stress levels obtained during the tests are compared with the cyclical stress level required to exceed the endurance limit of stainless steel, it is evident that the tube is safe from fatigue failure in use. This may be stated even though no attempt was made to reproduce the in-service environment.

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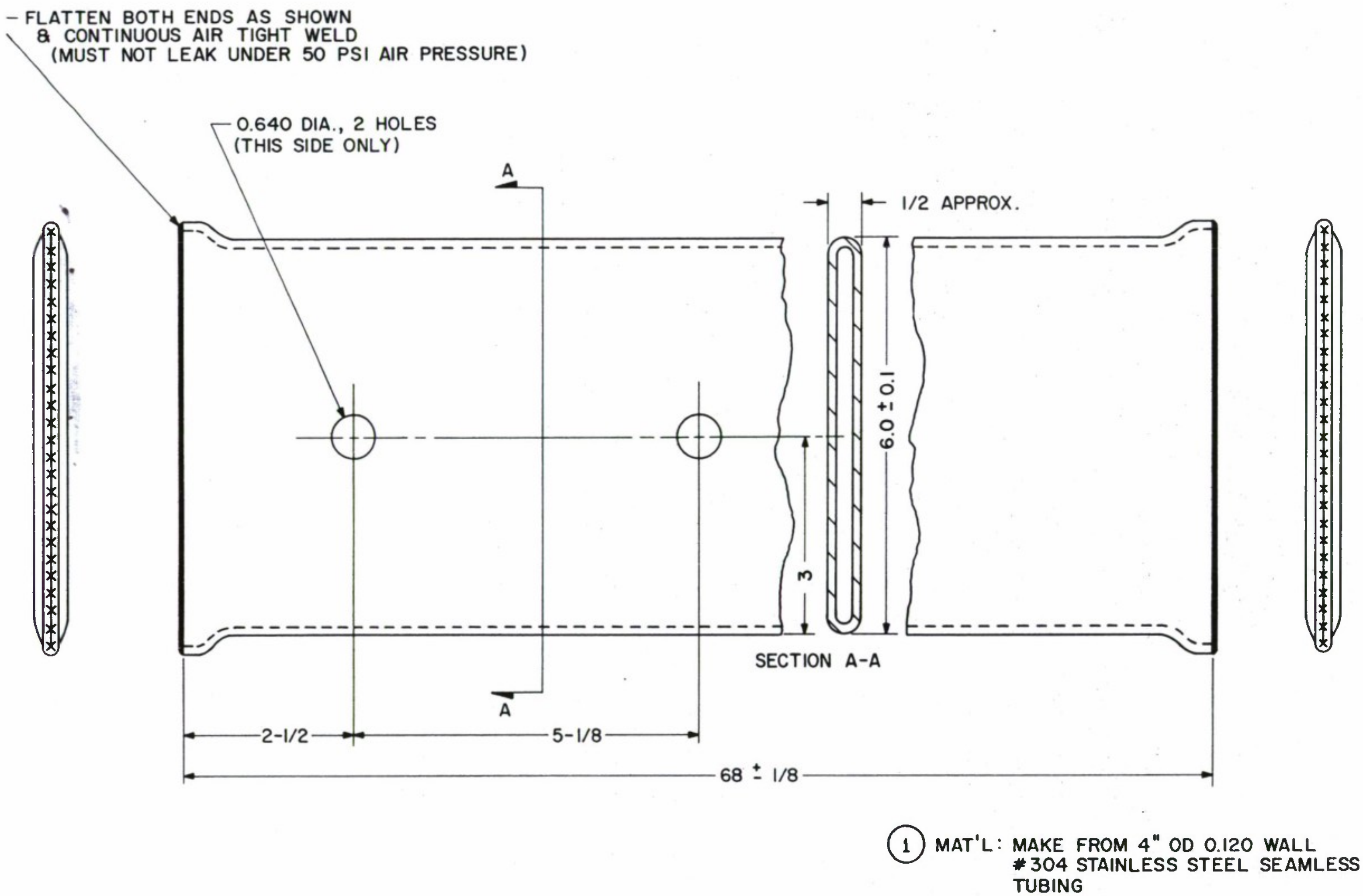

Figure 1

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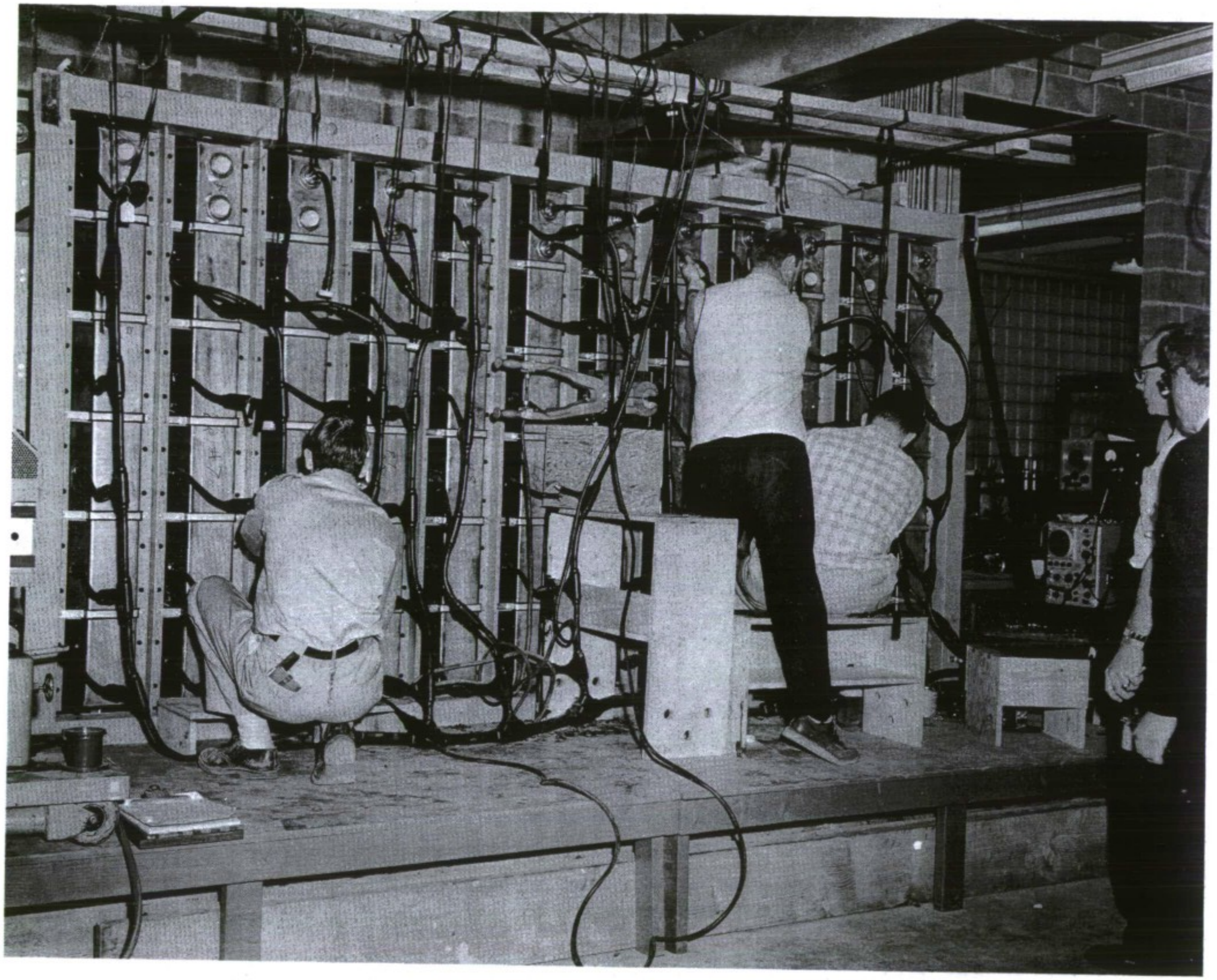

Figure 2

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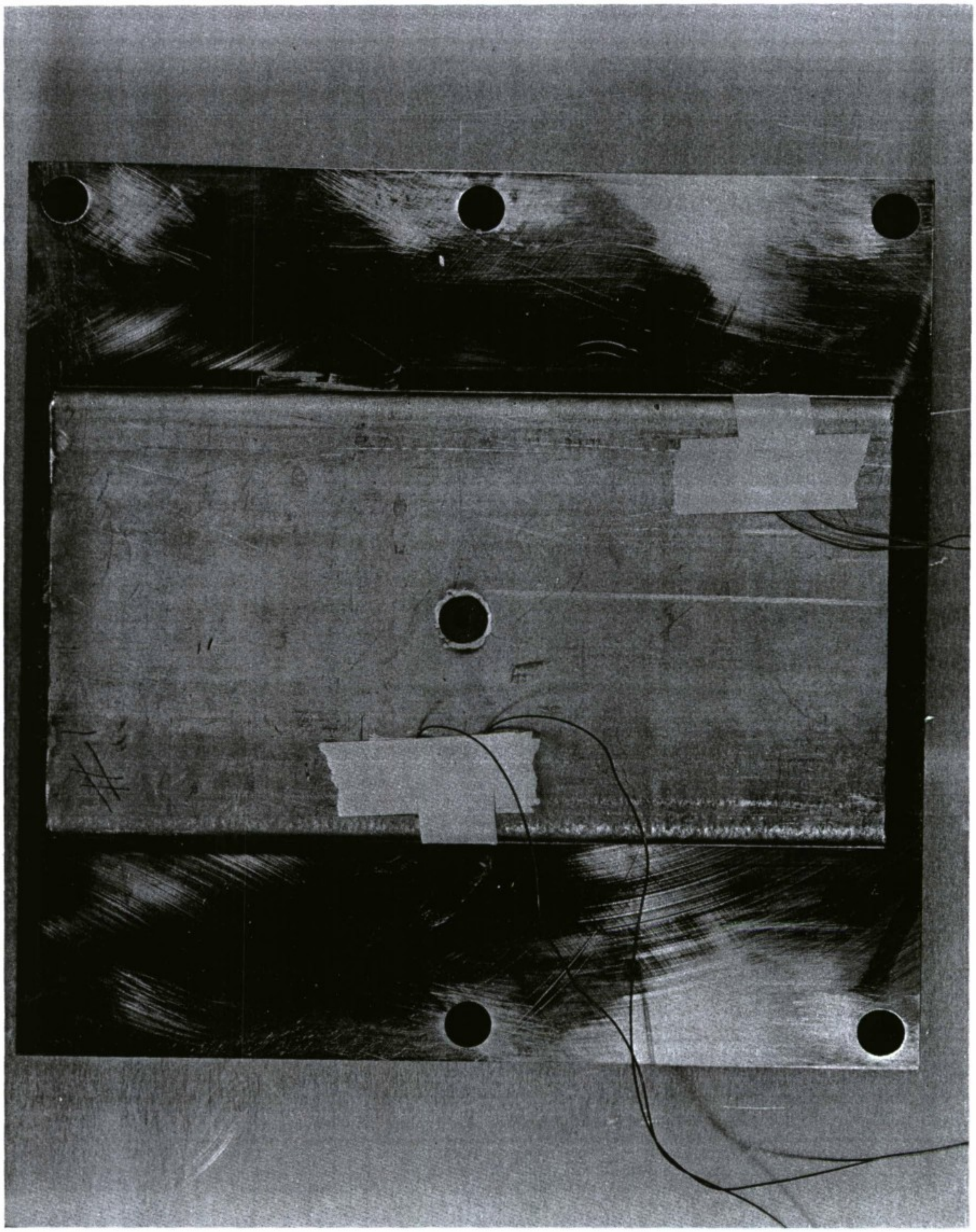

Figure 3

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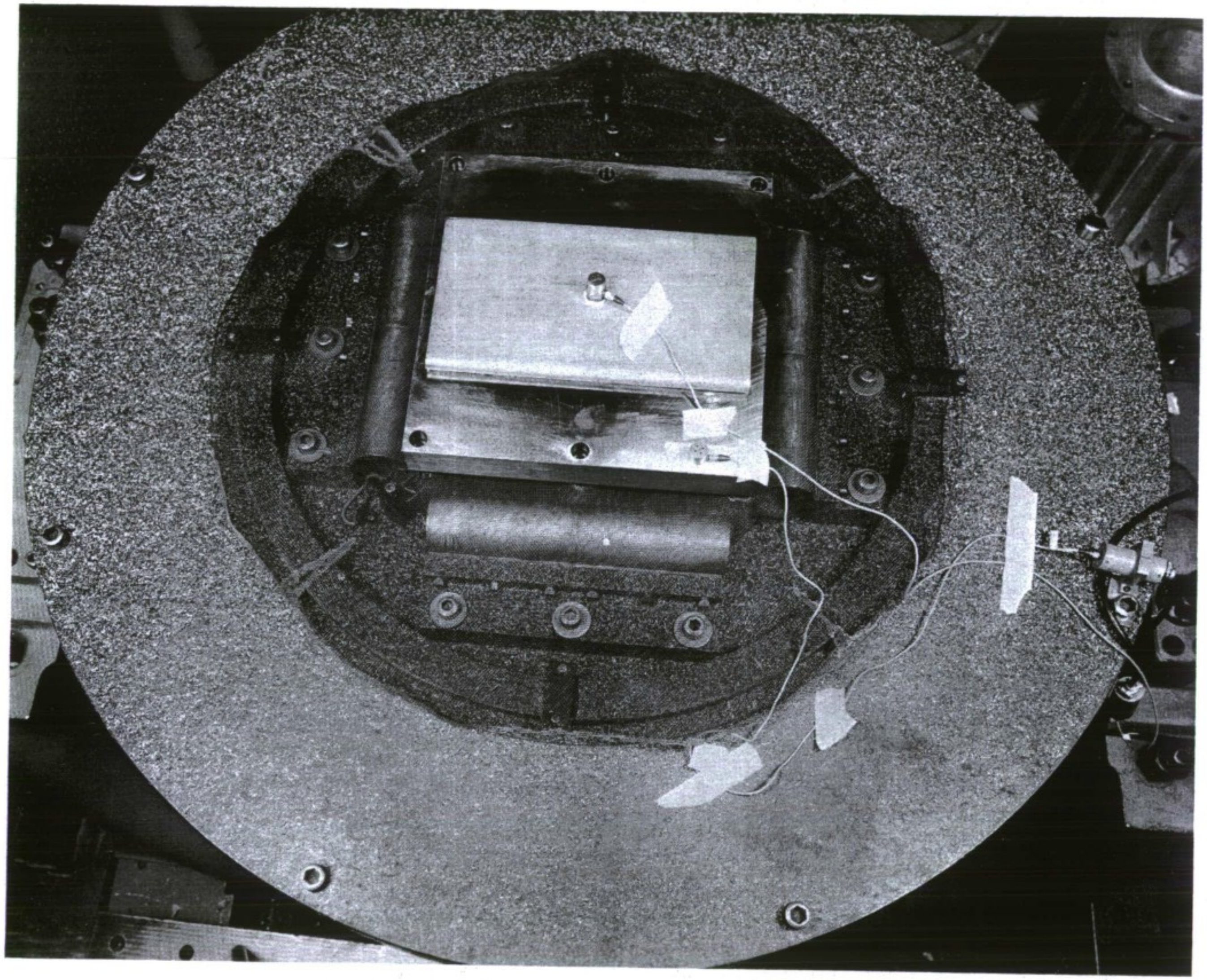

Figure 4

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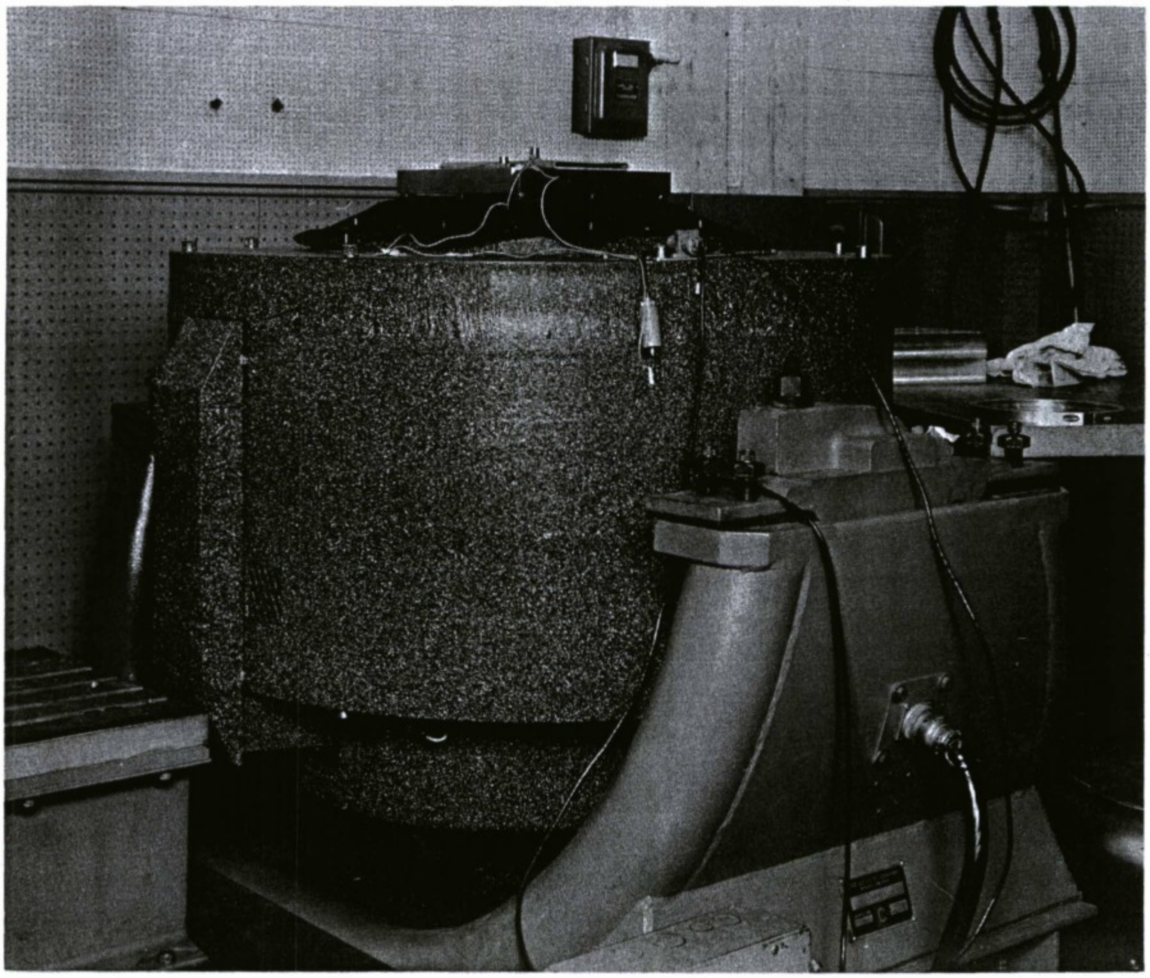

Figure 5

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SPECIMEN 1

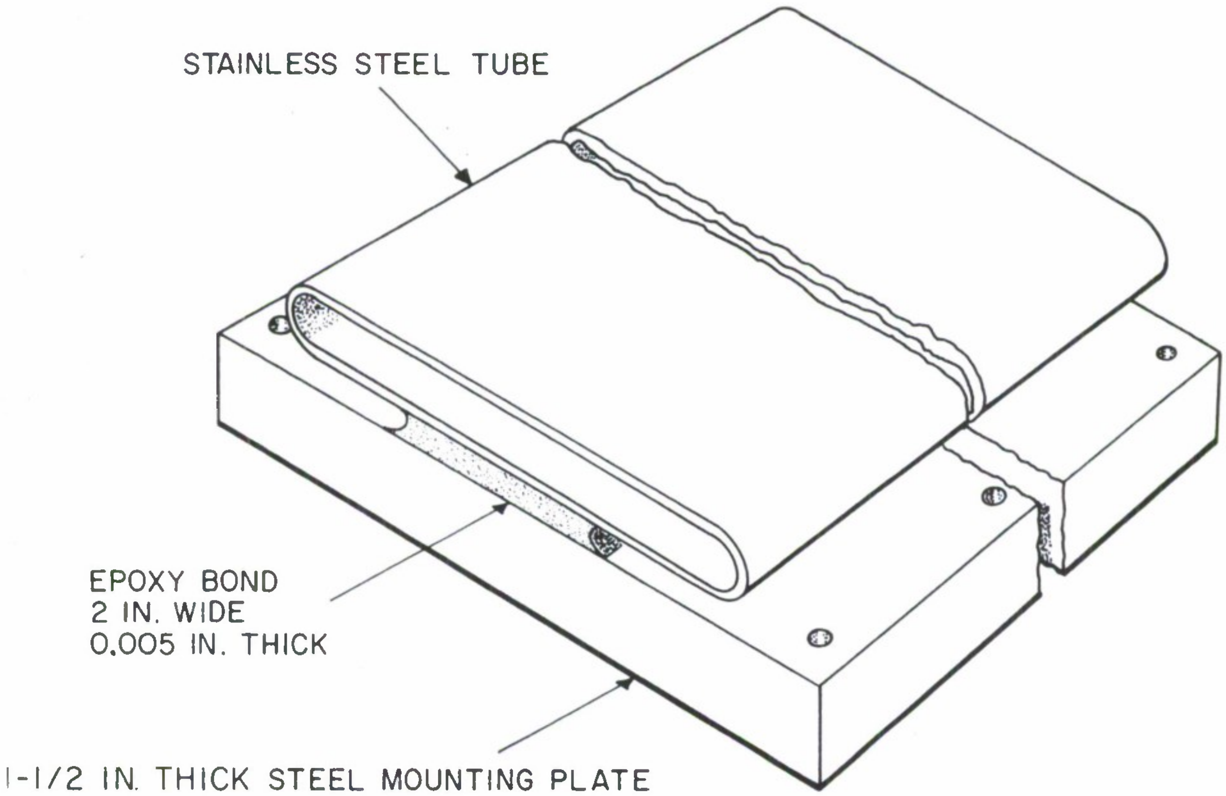

Figure 6

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SPECIMEN 2

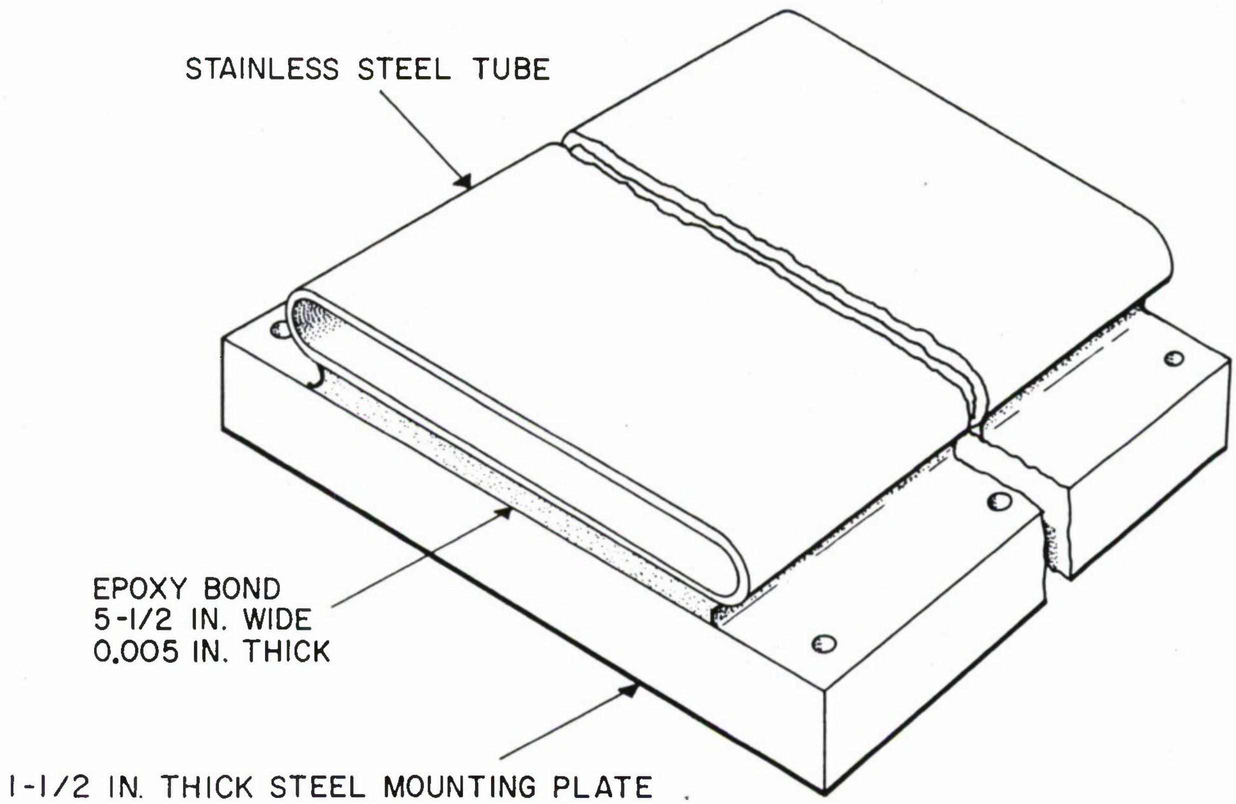

Figure 7

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